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Surface Relaxation Contributions to X-Ray Topographic Images of Micropipes in 6H-SiC Wafers

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Beamline: X19-C

Introduction: While in transmission electron microscopy, as a result of surface relaxation, dislocation images of screw dislocations perpendicular to a sample's surface appear irrespective of the $\mathbf{g}\bullet\mathbf{b} \times \mathbf{l} = 0$ condition, analogous dislocation contrast in the x-ray topography of basal-cut samples is not generally observed. Such a phenomenon is more likely in the x-ray topography of the giant Burgers vector dislocations associated with micropipes in SiC as their strain fields are much more extensive than those of dislocations of normal strength.

Methods and Materials: Topographs were obtained by allowing the white x-rays obtained from Beamline X19-C to fall onto SiC wafers. The diffracted beams were recorded on sheets of Kodak Industrex SR-5 film held normal to the incident beam direction either 10cm before or behind the crystal. For section topography, the synchrotron beam was restricted with a 50μm slit. Samples were thinned by grinding with graded diamond pastes and finishing with 0.25μm diamond paste on a napped cloth.

Results: Only in cases where a micropipe has a Burgers vector that is large among those of superscrew dislocations or when the sample is very thin, does this kind of superscrew dislocation contrast appear. The image that then occurs takes the form of a white oval inclined along the g-vector with a dark spike flaring from either end. An example of such an image appears in the center of figure 1(a), a transmission x-ray topograph taken using the g-vector $11\bar{2}0$. This superscrew dislocation image is surrounded by loops of a different type of dislocation, **D**, the Burgers vectors of which are of normal strength and lie in the basal plane of hexagonal SiC.

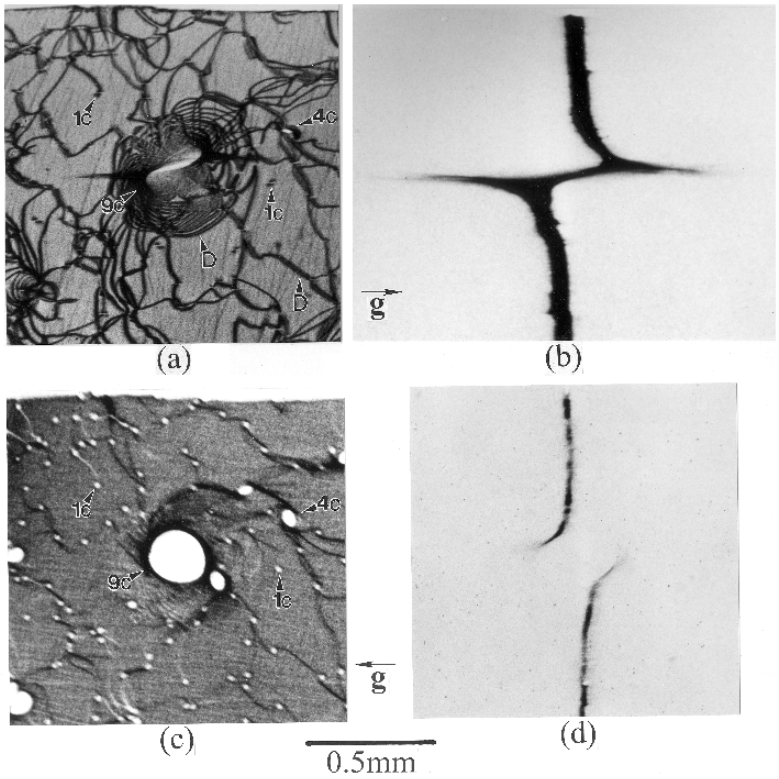

Figure 1. Synchrotron white-beam x-ray topographs of a 35μm thick 6H-SiC wafer. (a) $\mathbf{g} = 11\bar{2}0$ ($\lambda = 0.59$Å) (b) $\mathbf{g} = 11\bar{2}0$ (c) $\mathbf{g} = 00024$ ($\lambda = 1.24$Å) (d) $\mathbf{g} = 00024$.

Figure 1(c) is a x-ray topograph of the same area taken in the back-reflection geometry. It can be used to determine the position and Burgers vectors of its axial screw dislocations. Their characteristic dislocation image is a white circle surrounded by a black ring, with a diameter roughly proportional to the strength of the Burgers vector, starting with 1**c** axial screw dislocations, and increasing progressively larger. Some of these are labeled in figure 1(a) with their Burgers vectors expressed as multiples of **c**.

The prominent superscrew dislocation whose images are central in figures 1(a) and (c), is marked with the Burgers vector 9**c**. A series of axial screw dislocation images in their range of strengths is also present in figure 1(a) which corresponds to dislocations visible in figure 1(c). The size of the ovals increase as the Burgers vectors of their dislocations do. The ovals tilt slightly to either the right or left of the g-vector direction depending on the sign of their screw dislocations.

As earlier reported, back-reflection section topographs with the section slit positioned so that its beam falls across the axis of a superscrew dislocation results in a "two-tailed" image that indicates the tilts of the crystal lattice surrounding the dislocation (and its sign) [1]. A back-reflection section topograph of the central, large superscrew dislocation in figure 1(c) is shown in figure 1(d). A similar "two-tailed" section topograph image of this dislocation shown in figure 1(b) was obtained in the transmission geometry with a g-vector of $11\bar{2}0$. The direction of the tails' displacement in figure 1(b) is opposite to that in figure (d), showing that the tilt of the $(11\bar{2}0)$ planes relax along with the tilt of the basal planes.

Conclusions: Micropipes in SiC may exhibit surface relaxation contrast in x-ray topographs taken with basal plane reflections when the micropipes have large Burgers vectors and the sample is very thin.

References: [1]. X. R. Huang, M. Dudley, W. M. Vetter, W. Huang, S. Wang and C. H. Carter, Jr., "Direct Evidence of Micropipe-Related Pure Superscrew Dislocations in SiC," Appl. Phys. Lett., **74**, *353*, 1999.